10th Intl. Symposium on Physical Measurements and Signatures in Remote Sensing

ISPMSRS07 – March 12-14, 2007 – Davos, Switzerland

Modeling microwave brightness temperature in Antarctica.

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Themes:
Physical modeling in remote sensing
or
Data assimilation and integration of remote sensing with dynamic process models

Abstract

The Antarctic climate and its temporal variations are not well known because of the sparcity of meteorological stations. Observations by remote sensing are the only way to bypass this issue and to provide detailed information on the spatial and temporal variability of the Antarctic climate. Our research deals with estimating climatic variables from microwave radiometer observations (SMMR, SSM/I and AMSR-E) as this type of sensors presents strong advantages including: quasi-independence to atmospheric conditions and illumination, availability for nearly 3 decades and strong sensitivity to the variables of interest in climatology, e.g. snow temperature.

Estimating snow surface temperature and/or temperature profile from microwave brightness temperature requires knowing snow emissivity and microwave penetration length within the snow with a high accuracy. Empirical approaches consisting in combining brightness temperatures at various frequencies and polarizations have been inefficient to provide the required accuracy. To tackle this problem, we adopt a complex approach based on physical forward modeling followed by inversion (or data assimilation). This paper presents the forward modeling and the predicted spectral signature (emissivity and penetration length) over Antarctica.

The forward model takes near-surface meteorological data from ERA reanalysis as input and brightness temperatures at 19Ghz and 37Ghz (SSM/I frequencies) and V polarization as output. To achieve this prediction, the model is in fact a thermodynamic snow model that predicts temperature profile within the snow associated with an electromagnetic model that predicts microwave brightness temperatures from temperature profile. Both sub-models are intermediate-complexity so they require parameter calibration prior to prediction. The calibration is performed by a Monte-Carlo method called the Neighborhood Approximation. It provides the optimal parameter set (+pdf) including the emissivities and penetration lengths at selected frequencies for each

100kmx100km pixel in Antarctica. The calibrated model performs well, typical RMSE is 1.5K, except in zone where surface melting occurs.

Maps of emissivities and penetration lengths are interpreted both qualitatively and using a radiative transfer model (DMRT). Results show different facies in Antarctica: melting zones; zones with weak emissivity sensitivity to the frequency, thus revealing fine grains (~0.5mm); zones with strong sensitivity to frequency revealing coarse grains (>0.7mm) and zones with anomalous spectra, i.e. emissivity increasing with frequency.